

AMENDMENT TO THE SPECIFICATION

Please amend the paragraphs as follows without prejudice.

[0032] Referring now to Figures 2-1 through 5 of the drawings, a preferred embodiment of the cryogenic gas separation process of the present invention is shown configured for improved recovery of C3 compounds and heavier compounds. This process utilizes a two-column system that includes an absorber column and a sequentially-configured or downstream fractionation column. Absorber 18 is an absorber column having at least one vertically spaced tray, one or more packed beds, any other type of mass transfer device, or a combination thereof. Absorber 18 is operated at a pressure P that is substantially greater than and at a predetermined differential pressure from a sequential configured or downstream fractionation column. The predetermined differential pressure between the high pressure absorber and the fractionation column is about 50 psi – 350 psi in all embodiments of the invention. An example of this differential pressure would be if the absorber pressure is 800 psig, then the fractionation column pressure could be 750 psig to 450 psig, depending upon the differential pressure chosen. The preferable differential pressure is typically 50 psi. Fractionation column 22 is a fractionation column having at least one vertically spaced chimney tray, one or more packed bed or a combination thereof.

[0038] Fractionation column 22 is operated at a pressure P2 that is lower than and at a predetermined differential pressure DP from a sequential configured or upstream absorber column, preferably where P2 is above about 400 psia for such gas streams. For illustrative purposes, if P2 is 400 psia and DP is 150 psi, then P1 is 550 psia. The fractionation column feed rates, as well as temperature and pressure profiles, may be selected to obtain an acceptable separation efficiency of the compounds in the liquid feed streams, as long as the set differential pressure between the fractionation column and the absorber is maintained. In fractionation

column 22, first feed stream 48 and second feed stream 58 are supplied to one or more mid-column feed trays to produce a bottom stream 72 and an overhead stream 60. The fractionation column bottom stream 72 is cooled in bottoms exchanger 29 to produce an NGL product stream that contains substantially all of the heavy key components and heavies. A portion of fractionation column bottom stream 72a can be refluxed back to fractionation column 22 as shown in FIGS. 1 – 5.

[0039] Fractionation column overhead stream 60 is at least partially condensed in overhead condenser 20 by heat exchange contact with absorber overhead and bottom streams 46, 45 and/or first liquid portion stream 53. The at least partially condensed overhead stream 62 is separated in overhead separator 26 to produce a second vapor stream 66 that contains a major portion of methane, C2 and lighter compounds and a liquid stream that is returned to fractionation column 22 as fractionation reflux stream 64. Fractionation reflux stream 64 can be pumped to fractionation column 22 by using pump 25 as shown in FIGS. 1 – 3. The second vapor stream 66 is supplied to overhead compressor 27 and compressed essentially to the operating pressure P of absorber 18. The compressed second vapor stream 68 is at least partially condensed in overhead exchanger 20 by heat exchange contact with absorber overhead and bottom streams 46, 45 and/or first liquid portion stream 53. The condensed and compressed second vapor stream is supplied to absorber 18 as reflux stream 70. The compressed second vapor stream contains a major portion of the methane in the fractionation feed streams. When the heavy key component is C3 compounds and heavier compounds, then the compressed second vapor stream contains a major portion of the C2 compounds in the fractionation feed streams.

[0042] Figures 3 through 5 show alternate preferred embodiments of this invention. In Figure 3, a mechanical refrigeration system 30–33 is used to at least partially condense fractionation

column overhead stream 60 to produce an at least partially condensed stream 62. The at least partially condensed stream 62 is separated in separator 26, as noted above. Such mechanical refrigeration systems include propane refrigerant-type systems. — In Figure 4, an internal condenser 31 within fractionation column 22 is used to at least partially condense fractionation column overhead using stream 46. The absorber overhead stream 46 is warmed by heat exchange in the internal condenser and emerges as internal condenser outlet stream 76, which is warmed by heat exchange contact with other process streams in front end exchanger 12, as noted above. Figure 5 depicts the same process shown in Figure 4, but with the addition of the mechanical refrigeration system from the process depicted in Figure 3, which can be used as an external refrigeration system for the internal condenser. In this embodiment, absorber bottoms stream 45 is cooled in overhead exchanger 20 and front end exchanger 12 and then expanded in expander 23 prior to being sent to fractionation column 22 as a mid column feed stream 78. In all embodiments, the fractionation bottom stream contains substantially all of the heavies.

[0049] Fractionation column 22 is operated at a pressure that is substantially lower than of absorber 18, preferably above about 400 psia. The fractionation column feed rates as well as temperature and pressure profiles may be selected to obtain an acceptable separation efficiency of the compounds in the liquid feed streams, as long as the set differential pressure between the fractionation column and the absorber is maintained, i.e., 150 psi. First feed stream 158 and second fractionation feed stream 148 are supplied at one or more feed trays near a middle portion of fractionation column 22 to produce a bottom stream 172 and an overhead stream 160. The fractionation column bottom stream 172 is can be cooled in bottoms exchanger 29 to produce an NGL product stream that contains a majority of the heavy key component and heavies.

[0052] Figures 6a through 8 show other preferred embodiments of the cryogenic gas separation process for improved recovery of C₂ compounds and heavier compounds in which the high pressure absorber receives streams rich in C₂ compounds and lighter compounds to improve separation efficiency. Figure 6a contains another embodiment of the process shown in Figure 6. In Figure 6a, a cold absorber 14-114 with one or more mass transfer stages is used instead of a cold separator 1814. Feed stream 40 is split into two separate feed streams 40a and 40b in this process variation. Stream 40a is cooled in front end exchanger 12 by heat exchange contact with the absorber overheads stream 150 and emerges as stream 40c. Stream 40b is cooled in the reboilers 32a and 32b by heat exchange contact with streams 126 and 127 respectively and emerges as stream 40d. The colder of the two streams, 40c and 40d, is fed to the top of the cold absorber 14 with the warmer of the two streams, 40c and 40d, being fed to the bottom of the cold absorber 14. Additionally, at least a portion of the first liquid stream 144 can be split as stream 144a and combined with the second expanded vapor stream 142b discussed above.

[0054] Figure 7a contains another embodiment of the process shown in Figure 7. In Figure 7a, a cold absorber 14-114 with one or more mass transfer stages is used instead of a cold separator 1814. Feed stream 40 is split into two separate feed streams 40a and 40b in this particular embodiment of the process. Stream 40a is cooled in front end exchanger 12 by heat exchange contact with the absorber overhead stream 150 and emerges as stream 40c. Stream 40b is cooled in the reboilers 32a and 32b by heat exchange contact with streams 126 and 127 respectively and emerges as stream 40d. The colder of the two streams, 40c and 40d, is fed to the top of the cold absorber 14-114 with the warmer of the two streams, 40c and 40d, being fed to the bottom of the cold absorber 14114.

[0055] Figure 8 depicts a further embodiment of the C2+ recovery process. In this particular process embodiment, the inlet gas stream 40 is cooled in front end exchanger 12 and fed to cold separator 14. The first vapor stream 142 is expanded in expander 16 and fed to absorber 18 as expanded vapor stream 142a. Expanded vapor stream 142a is fed to the lower portion of absorber 18 in its entirety, as opposed to being split into streams 142a and 142b as in previously discussed embodiments. Two other absorber feed streams exist in the present embodiment of the process. Fractionation column overhead vapor stream 160 is compressed and expanded in compressor 27 to the same pressure as the absorber 18 and exits as compressed second vapor stream 168. Fractionation bottom stream contains substantially all of the heavy key component. Compressed second vapor stream 168 is at least partially condensed in overhead exchanger 20 and fed to absorber 18 as second absorber feed stream 151. A second expanded vapor stream ~~142b-151~~ of residue gas stream 152 is heated in reboilers 32a and 32b, at least partially condensed in overhead exchanger 20, ~~compressed-and expanded to the same pressure as the absorber 18 in compressor-expander 35~~, and fed to the absorber 18 as absorber feed stream 170.